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COMMITTEE OF EXPERTS ON THE
TRANSPORT OF DANGEROUS GOODS

Sub-Committee of Experts on the
Transport of Dangerous Goods
(Fifteenth session,
Geneva, 29 June-10 July 1998,
agenda item 5 (a))

MISCELLANEOUS DRAFT AMENDMENTS TO THE MODEL REGULATIONS ON THE TRANSPORT OF DANGEROUS GOODS

Other draft amendments

Listing and classification
Lithium batteries

Transmitted by the experts from France, Germany and the United States of America

Introduction

1. The Expert from the United States submitted a document to the fourteenth session of the Sub-Committee that proposed various amendments to the provisions for the transport of lithium batteries (see document ST/SG/AC.10/C.3/1997/83). These proposals were intended to take account of advancements experienced in the development of new lithium battery technologies, as well as increases in the size of lithium batteries now being produced for various applications, including for purposes of electric vehicle propulsion. Owing to lack of time, the Sub-Committee was not able to consider these proposals. However, detailed written comments on the proposals were provided to the expert from the United States by the experts from France and Germany. This document presents revised proposals that take into account the written comments offered on document ST/SG/AC.10/C.3/1997/83, as well as the results of subsequent informal discussions between the experts from France, Germany and the United States.

2. In general, the explanation of, and rationale for the changes proposed in document ST/SG/AC.10/C.3/1997/83 remain valid. Accordingly, those arguments are not reproduced in this document. The discussion section of this document only addresses new or additional issues not examined in the previous document, or issues where further explanation is considered necessary. However, to facilitate consideration of the specific amendments proposed, all of the amendments proposed in document ST/SG/AC.10/C.3/1997/83, modified, when appropriate, by the comments received, subsequent informal discussions between experts, and/or to improve clarity, are presented herein.

Discussion of additional issues

3. Aggregate Lithium Content.

3.1 Further clarification is considered appropriate with respect to the introduction of the term "lithium content", as proposed in document ST/SG/AC.10/C.3/1997/83. It was proposed that the 12 g per cell and 500 g per battery lithium or lithium alloy quantity limitations be removed from Special Provision 230, and be used only in the Manual of Tests and Criteria for purposes of determining the number and condition of cells and batteries to be tested. A note to this effect would be added to Special Provision 230. Moreover, owing to the fact that lithium can be present in a variety of forms (e.g., pure lithium metal, combined with chemically inert metals as metal alloys, or intercalated into chemically inert carbon or graphite hosts), it was further proposed that where the 12 g/cell and 500 g/battery mass limits would continue to appear in the Test Manual, these limits would apply to the aggregate "lithium content" of the negative electrodes and not to the aggregate mass of "lithium or lithium alloy" in cells or batteries (as it appears in the current Recommendations).

3.2 Use of this term allows the mass limitations to be applied on the basis of what may be viewed as an "equivalent" lithium content. That is, if lithium is alloyed or intercalated in an inert host, the mass limitation would not be applied to the mass of the alloy or host (of which only a fraction is lithium), but rather to the mass of lithium present in the alloy or host. It is considered appropriate to apply this concept in that the capacity of a cell or battery to store energy (and, therefore, its potential heat generating hazard in transport), is directly related to the quantity of lithium present, not to the mass of any alloy or inert host plus the lithium that may be contained therein. Thus, regardless of the form in which the lithium is present (pure, alloyed, or intercalated in an inert host), the mass limitations would be applied on the basis of the equivalence to pure lithium. The actual aggregate anode lithium content of a battery is the anode lithium content of the cell multiplied by the number of cells in the battery.

3.3 As a consequence of the introduction of this concept into the Test Manual, similar terminology should be employed in the text of Special Provision 188 (in which mass limitations are also specified in terms of mass of "lithium or lithium alloy"). However, this consequential change had not been proposed in document ST/SG/AC.10/C.3/1997/83. Appropriate amendments in this regard are proposed in a separate document.

4. Expression of cell and battery lithium content mass limitations in Test Manual.

4.1 As stated above, it was proposed in document ST/SG/AC.10/C.3/1997/83 that the 12g per cell and 500 g per battery limitations on lithium content that now appear in Special Provision 230 should instead appear only in the Manual of Tests and Criteria for purposes of specifying the number and condition of cells and batteries required to be tested. Thus, in effect these limitations would be used to distinguish between "large" and "small" cells and batteries for testing purposes. In the relevant amendments proposed to the Test Manual, expression of the testing distinctions between such "large" and "small" cells and batteries resulted in repetitive use of lengthy qualifying phrases such as "for cells in which the lithium content of the anode is not more than 12 g, and for batteries in which the aggregate lithium content of all cell anodes is not more than 500 g...." To avoid repetitive use of such qualifying phrases, and, thereby, improve the clarity and editorial presentation of the relevant test requirements, it is proposed herein to use the 12 g and 500 g limitations in appropriate definitions for "small" and "large" cells and batteries. For example, a "large cell" would be defined as a cell in which the lithium content of the anode is more than 12 g, and a "large battery" would be defined as a battery in which the aggregate lithium content of all cell anodes is more than 500 g. These definitions would appear only once in 38.3.3.2 of the Test Manual, with the text of the actual tests being simplified by using the defined terms "small cell", "small battery", "large cell" and "large battery", as appropriate.

5. Test T.1.

5.1 Comments on document ST/SG/AC.10/C.3/1997/83 suggested that a modification was necessary to the extreme temperature test provisions in Test T.1 to properly take account of the practical aspects of testing and shipping large cells and batteries. In this regard, it was noted that owing to the possible need for mechanical handling of very large batteries, the time period between storage at the high and low temperatures should be extended from 5 to 10 minutes. This comment has been incorporated into the proposed amendments to Test T.1.

6. Test T.2.

6.1 Comments on document ST/SG/AC.10/C.3/1997/83 suggested that certain modifications were necessary to the shock test provisions in Test T.2 to properly take account of the practical aspects of testing and shipping large cells and batteries. With regard to the shock test provisions, it was noted that the required peak acceleration currently specified (125 to 175 times the local acceleration of gravity ("g")) is not realistic for large cells and batteries in that the higher mass of such articles results in excessively large forces being applied in testing. It was suggested that for such cells and batteries, the peak acceleration required should be not less than 50 g, which must be achieved over a maximum duration of 11 milliseconds (as is provided in Table II of IEC Standard 68-2-27). These comments have been incorporated into the proposed amendments to Test T.2.

7. Test T.3.

7.1 Comments on document ST/SG/AC.10/C.3/1997/83 suggested that certain modifications were necessary to the shock and charge test provisions in Test T.3 to properly take account of the practical aspects of testing large cells and batteries. With regard to the shock test provisions, the same suggestions were made as were described above in relation to the shock test provisions of

Test T.2. With regard to the charge test, in order to exclude the need to take account of the current draw experienced during short-term power pulses it was proposed to clarify that the current draw required to be maintained is the maximum "continuous" current specified by the manufacturer. In addition, if in testing certain types of cells it is found impossible to achieve this level of current draw when employing the testing procedure prescribed in 38.3.4.3.3 (e.g., for cell technologies that are designed to operate most efficiently at temperatures well above the temperature at which the cells are tested or typically transported), it was suggested to limit the required current draw to the maximum attainable under the prescribed test procedure at the ambient temperature at which the test is performed. These comments have been incorporated into the proposed amendments to Test T.3.

8. Test T.4.

8.1. In document ST/SG/AC.10/C.3/1997/83, the expert from the United States drew the Sub-Committee's attention to certain deficiencies with the Test T.4 (internal short circuit) test procedure that have come to light in attempting to apply the procedure to the testing of large cells. Comments submitted supported the need for changes to the procedure for performing the T.4 test. Specifically, it was suggested that the diameter of the rod used to apply the "crushing" force should vary in proportion to the size of the cell tested, with the rod diameter being not less than 50% of the smallest cell overall dimension (or 6 mm, whichever is greater). In addition, it was suggested that the test should specify that the force be applied to cell faces that are perpendicular to the terminal face, in the case of prismatic cells. Finally, since large cells may require very high, and, therefore, unrealistic forces to be applied in order to induce an internal short circuit through cell deformation, it was also suggested that the maximum force required to be applied in the test be limited to 10 kN (one metric ton). These comments have been incorporated into the proposed amendments to Test T.4.

9. Test T.5.

9.1 Comments on document ST/SG/AC.10/C.3/1997/83 suggested that certain modifications were necessary to the shock and low capacity cell test provisions in Test T.5 to properly take account of the practical aspects of testing and shipping large cells and batteries. With regard to the shock test provisions, the same suggestions were made as were described above in relation to the shock test provisions of Test T.2. With regard to the low capacity cell test provisions, it was noted that for large batteries it may not always be possible (for reasons such as are outlined in 7.1, above) to achieve a current draw corresponding to the maximum discharge rate specified by the manufacturer when employing the testing procedure prescribed in 38.3.4.5.3.3. In such cases, it was suggested to limit the required current draw to the maximum attainable under the prescribed test procedure at the ambient temperature at which the test is performed. These comments have been incorporated into the proposed amendments to Test T.5.

10. Test T.6.

10.1 No written comments were received regarding the amendments proposed in document ST/SG/AC.10/C.3/1997/83 relative to Test T.6. However, in subsequent discussions between experts regarding the maximum discharge current required to be achieved during the forced discharge testing of large cells, it was again noted that it may not always be possible (for reasons

such as are outlined in 7.1, above) to achieve a current draw corresponding to the maximum current specified by the manufacturer when employing the testing procedure prescribed in 38.3.4.6.3. It was suggested that in such cases the current draw required to be achieved be limited to the maximum attainable under the prescribed test procedure at the ambient temperature at which the test is performed. This comment has been incorporated into the proposed amendments to test T.6.

Proposals

11. In light of the foregoing, the following amendments to the UN Recommendations are proposed:

a) In Special Provision 230:

(i) Add a new first sentence to read:

"This entry applies to cells and batteries containing lithium in any form, including lithium polymer and lithium ion cells and batteries."

(ii) Delete (b) and (c), and redesignate (d), (e), (f) and (g) as (b), (c), (d) and (e), respectively;

(iii) Revise new (d) [i.e., the current (f)] to read:

"each battery containing cells or series of cells connected in parallel is equipped with effective means as necessary to prevent dangerous reverse current flow (e.g., diodes, fuses, etc.);"

b) In Special Provision 240, replace the words "or sodium batteries" after "powered by wet batteries" by the words "sodium batteries, or lithium batteries".

c) Add a new Special Provision 28A to UN 3090 to read:

28A New, uncycled and uncharged lithium ion cells and batteries are not subject to these regulations if:

a) The electrolyte does not meet the definition of any class or division in these regulations; or

b) If the electrolyte meets the definition of a hazard class or division in these regulations, the electrolyte will not flow from a ruptured or cracked case and there is no free liquid to flow.

12. In addition, the following amendments are proposed to the Manual of Tests and Criteria:

a) In 38.3.3.2, add the following new definitions in appropriate alphabetical sequence:

"*Large battery* means a battery in which the aggregate lithium content of all anodes, when fully charged, is more than 500 g. (For an explanation of "lithium content", see Special Provision 188.)"

"*Large cell* means a cell in which the lithium content of the anode, when fully charged, is more than 12 g."

"*Small battery* means a battery composed of small cells, and in which the aggregate lithium content of all cell anodes, when fully charged, is not more than 500 g."

"*Small cell* means a cell in which the lithium content of the anode, when fully charged, is not more than 12 g."

c) In 38.3.4.1 ("Test T.1"):

1) Revise the introductory text in 38.3.4.1.2.2 to read:

"For small cells and small batteries, the number and condition of cells and batteries to be tested are as follows:" [(a) to (f) unchanged]

2) Add a new 38.3.4.1.2.3 to read:

"For large cells and large batteries, the number and condition of cells and batteries to be tested are as follows:

(a) Only when cells are to be transported individually --

(i) Ten cells which should be tested, at first cycle, in both fully charged and fully discharged states; and

(ii) Ten cells which should be tested after deep cycling a minimum of 50 times, in both fully charged and fully discharged states.

(b) Four batteries, which should be tested, at first cycle, in both fully charged and fully discharged states.

(c) Four batteries, which should be tested after deep cycling a minimum of 50 times, in both fully charged state and fully discharged states."

3) In 38.3.4.1.3.2, replace the time period "5 minutes" by the time period "10 minutes" in the second sentence.

d) In 38.3.4.2 ("Test T.2"):

1) In 38.3.4.2.2.1, revise the second sentence to read:

"The shock test apparatus should be constructed to give the minimum accelerations required by 38.2.3.2.3.2 for the size of cell or battery being tested, e.g., apparatus to IEC 68-2-27."

2) Revise the introductory text in 38.3.4.2.2.2 to read:

"For small cells and small batteries, the number and condition of cells and batteries to be tested are as follows:" [(a) to (f) unchanged]

3) Add a new 38.3.4.2.2.3 to read:

"For large cells and large batteries, the number and condition of cells and batteries to be tested are as follows:

(a) Only when cells are to be transported individually --

(i) Ten cells which should be tested, at first cycle, in both fully charged and fully discharged states; and

(ii) Ten cells which should be tested after deep cycling a minimum of 50 times, in both fully charged and fully discharged states.

(b) Four batteries, which should be tested, at first cycle, in both fully charged and fully discharged states.

(c) Four batteries, which should be tested after deep cycling a minimum of 50 times, in both fully charged state and fully discharged states."

4) In 38.3.4.2.3.2, replace the last two sentences of the current text with the following:

"In each case, the cell or battery is accelerated in such a manner that:

(a) For small cells and small batteries, during the first three milliseconds the minimum average acceleration is 75 times the local acceleration due to gravity, and the peak acceleration is between 125 and 175 times the local acceleration of gravity; or

(b) For large cells and large batteries, a peak acceleration of not

less than 50 times the local acceleration of gravity is achieved over a maximum duration of 11 milliseconds."

e) In 38.3.4.3 ("Test T.3"):

1) In 38.3.4.3.2.1, revise the second sentence to read:

"The shock test apparatus should be constructed to give the minimum accelerations required by 38.2.3.2.3.2 for the size of cell or battery being tested, e.g., apparatus to IEC 68-2-27."

2) Revise 38.3.4.3.2.2 to read:

"For small cells and small batteries, the number and condition of cells and batteries to be tested are as follows:" [38.3.4.3.2.2.1 to 38.3.4.3.2.2.3 unchanged]

3) Add a new 38.3.4.3.2.3 to read:

"For large cells and large batteries, tests need not be performed on batteries, and the number and condition of cells to be tested are as follows:

(a) Ten cells which should be tested, at first cycle, in the fully charged state; and

(b) Ten cells which should be tested after deep cycling a minimum of 50 times, in the fully charged state."

4) In 38.3.4.3.3.2, replace the last two sentences of the current text with the following:

"In each case, the cell or battery is accelerated in such a manner that:

(a) For small cells and small batteries, during the first three milliseconds the minimum average acceleration is 75 times the local acceleration due to gravity, and the peak acceleration is between 125 and 175 times the local acceleration of gravity; or

(b) For large cells, a peak acceleration of not less than 50 times the local acceleration of gravity is achieved over a maximum duration of 11 milliseconds."

5) In 38.3.4.3.3.3, amend the fifth sentence (by adding the word "continuous" after the word "maximum"), and insert a new sixth sentence, so that the fifth and sixth sentences read:

"Where the cell or battery contains no protective devices, the resistive load is such that the average current draw is the same as the maximum continuous discharge current specified by the manufacturer. When for large cells this average current draw cannot be achieved employing this test procedure, the current draw required is the maximum current attainable according to this test procedure at the ambient temperature at which the test is performed."

f) In 38.3.4.4 ("Test T.4"):

1) In 38.3.4.4.2.1, replace the words "a 6 mm (diameter) rod" with the words "a rod with a diameter of at least 50% of the smallest cell overall dimension, or 6 mm, whichever is greater".

2) Transfer the first two sentences of 38.3.4.4.2.2 to the end of the "Introduction" section, (i.e., 38.3.4.4.1), and revise the third sentence to read:

"For small cells, the number and conditions of cells to be tested are as follows:" [(a) to (d) unchanged]

3) Add a new 38.3.4.4.2.3 to read (reminder of paragraphs to be renumbered):

"For large cells, ten cells should be tested, at first cycle, in the fully charged state."

4) Revise 38.3.4.4.3 to read:

"Each cell is deformed until the open circuit voltage drops abruptly or is reduced to at least one third, or until a maximum force of 10 kN is applied. The deformation is effected by placing the rod between one jaw of the clamping device and the cell and applying force. In the case of prismatic cells, the force is to be applied to each face that is perpendicular to the terminal face. The applied force is removed at the point at which the cell voltage drops, or when the maximum 10 kN force is achieved, whichever occurs first.

g) In 38.3.4.5 ("Test T.5"):

1) In 38.3.4.5.2.1, revise the second sentence to read:

"The shock test apparatus should be constructed to give the minimum accelerations required by 38.2.3.5.3.2 for the size of cell or battery being tested, e.g., apparatus to IEC 68-2-27."

2) Revise the introductory text in 38.3.4.5.2.2 to read:

"For small cells and small batteries, the number and condition of cells and batteries to be tested are as follows:" [(a) and (b) unchanged]

3) Add a new 38.3.4.5.2.3 to read:

"For large cells and large batteries, batteries should be constructed with uncycled cells except for one in each series string which is deep cycled a minimum of 50 times, and then brought to a 60 % state of charge. Four batteries are tested at first cycle in the fully charged state."

4) In 38.3.4.2.3.2, replace the last two sentences of the current text with the following:

"In each case, the cell or battery is accelerated in such a manner that:

(a) For small cells and small batteries, during the first three milliseconds the minimum average acceleration is 75 times the local acceleration due to gravity, and the peak acceleration is between 125 and 175 times the local acceleration of gravity; or

(b) For large cells and large batteries, a peak acceleration of not less than 50 times the local acceleration of gravity is achieved over a maximum duration of 11 milliseconds."

5) In 38.3.4.5.3.3, insert a new penultimate sentence to read:

"When for large batteries this average current draw cannot be achieved employing this test procedure, the current draw required is the maximum current attainable according to this test procedure at the ambient temperature at which the test is performed."

h) In 38.3.4.6 ("Test T.6"):

1) Revise 38.3.4.6.2.2 to read:

"For small cells and small batteries, the number and condition of cells and batteries to be tested are as follows:" [38.3.4.6.2.2.1 to 38.3.4.6.2.2.3 unchanged]

2) Add a new 38.3.4.6.2.3 to read:

"For large cells and large batteries, tests need not be performed on batteries, and need only be performed on component cells when the battery voltage does not exceed 12 volts. When required to be tested, the number and condition of cells to be tested are as follows:

(a) Ten cells which should be tested, at first cycle, in the fully discharged state.

(b) Ten cells which should be tested, after deep cycling a minimum of 50 times, in the fully discharged state.

3) In 38.3.4.6.3, insert a new sentence following the sixth sentence (i.e., the sentence beginning "Where the cell or battery contains no protective devices...") to read:

"When for large cells this average current draw cannot be achieved employing this test procedure, the current draw required is the maximum current attainable according to this test procedure at the ambient temperature at which the test is performed."

i) In 38.3.4.7 ("Series T test criteria and method of assessing results"), 38.3.4.7.2 would be amended by replacing the words "subject to the mass requirements in Special Provision 230" with the words "not excepted from these Recommendations according to 38.3.4.7.1."